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Sakai et al.

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(54) **STRUCTURE FOR EXTRACTING COMPRESSED AIR FROM COMPRESSOR OF GAS TURBINE ENGINE AND GAS TURBINE ENGINE WITH THE STRUCTURE**

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F04D 27/02	(2006.01)
F02C 9/18	(2006.01)
F04D 29/52	(2006.01)

(52) **U.S. Cl.**

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(58) **Field of Classification Search**

CPC F02C 6/08; F02C 9/18; F04D 27/0207; F04D 27/0215

See application file for complete search history.

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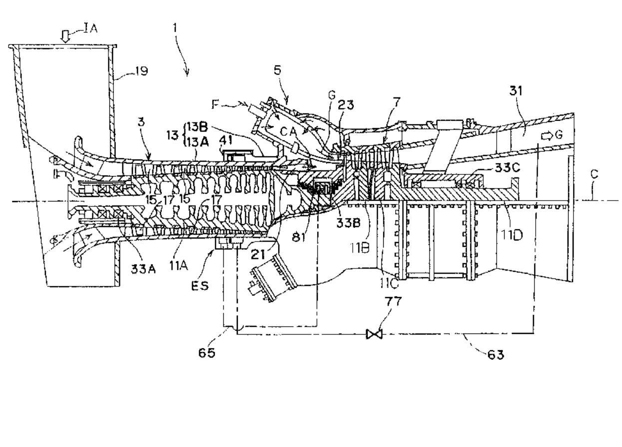
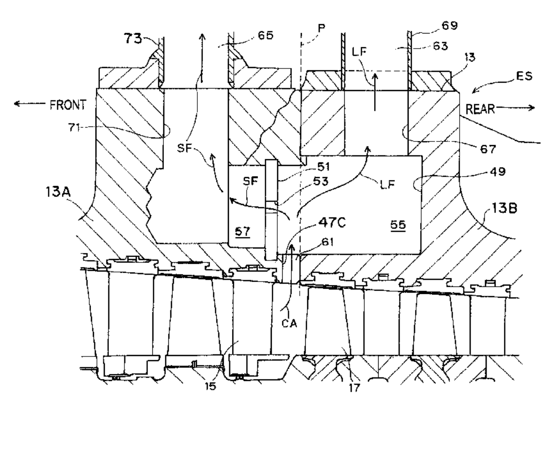
(57) **ABSTRACT**

Provided is a structure of a gas turbine engine for extracting a part of compressed air generated by a compressor. The structure comprises a cylindrical housing having an annular portion extending around the compressing chamber to define an annular chamber, an annular partition dividing the annular chamber into first and second plenum chambers. The cylindrical housing has first apertures to communicate between the compressing chamber and the first plenum chamber. The partition has second apertures to communicate between the first and second plenum chambers. The first and second apertures are configured so that that the first apertures have a first total cross-sectional area and the second apertures have a second total cross-sectional area which is smaller than the first total cross-sectional area.

10 Claims, 5 Drawing Sheets





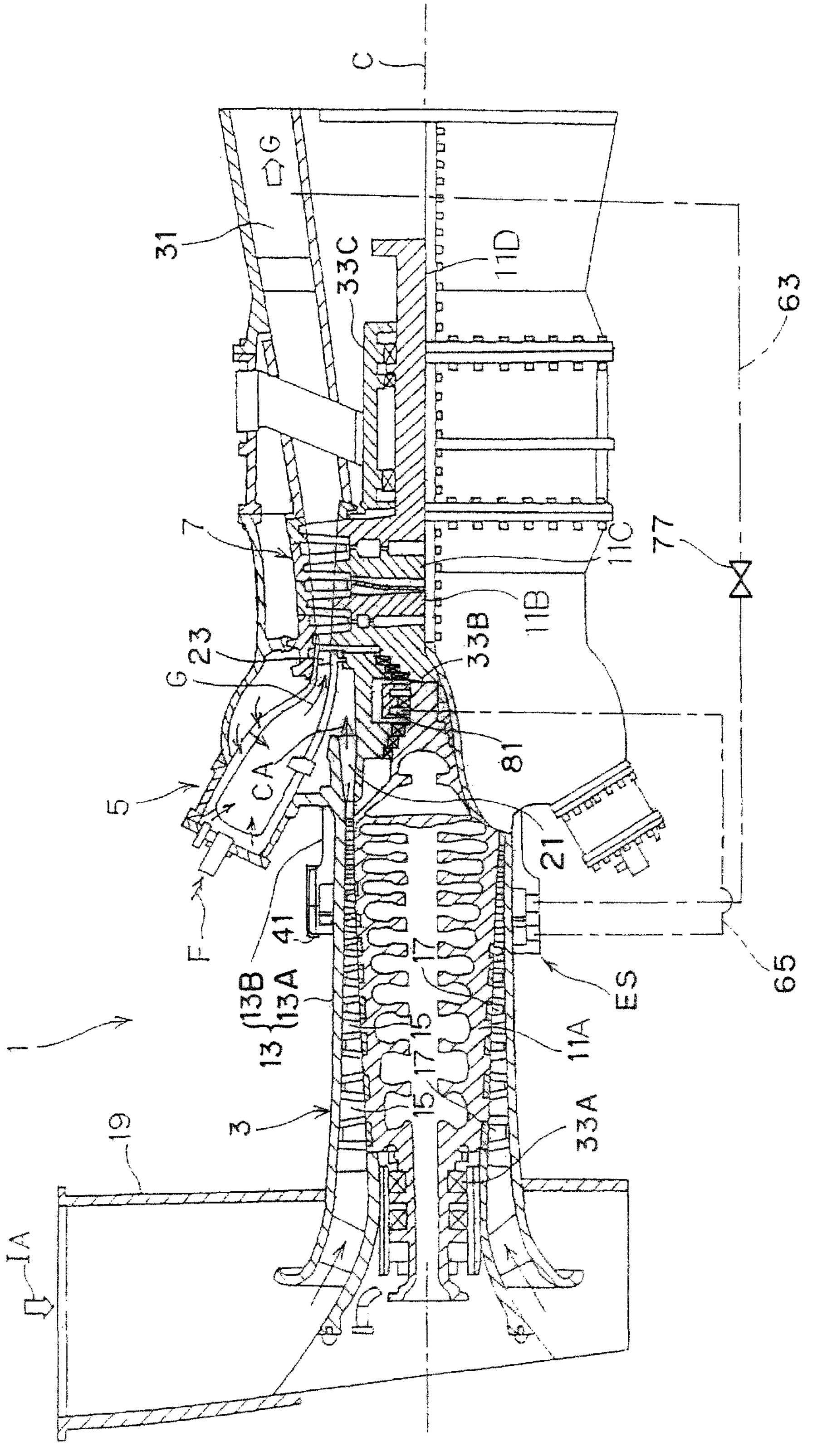


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Fig.1

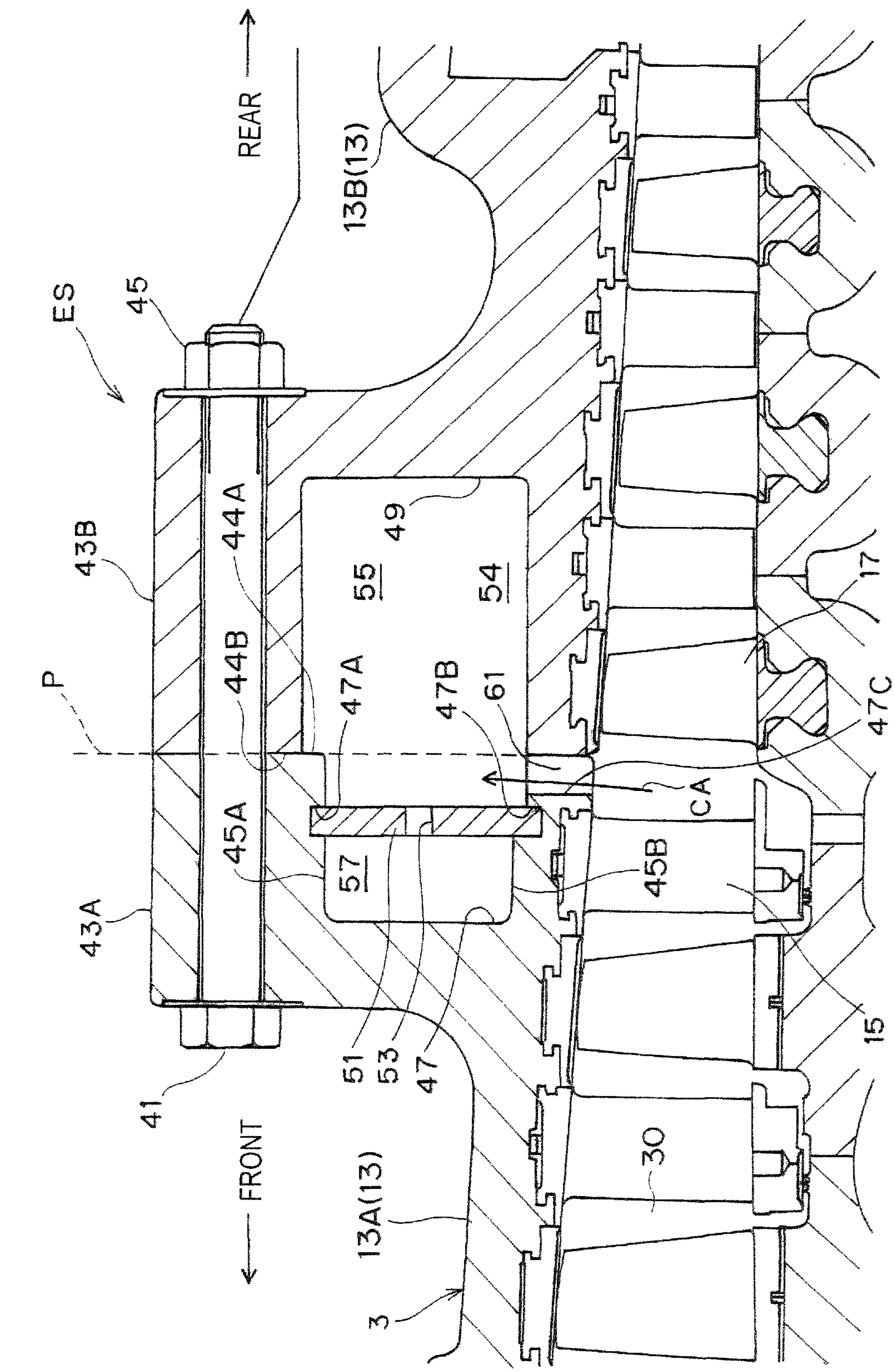
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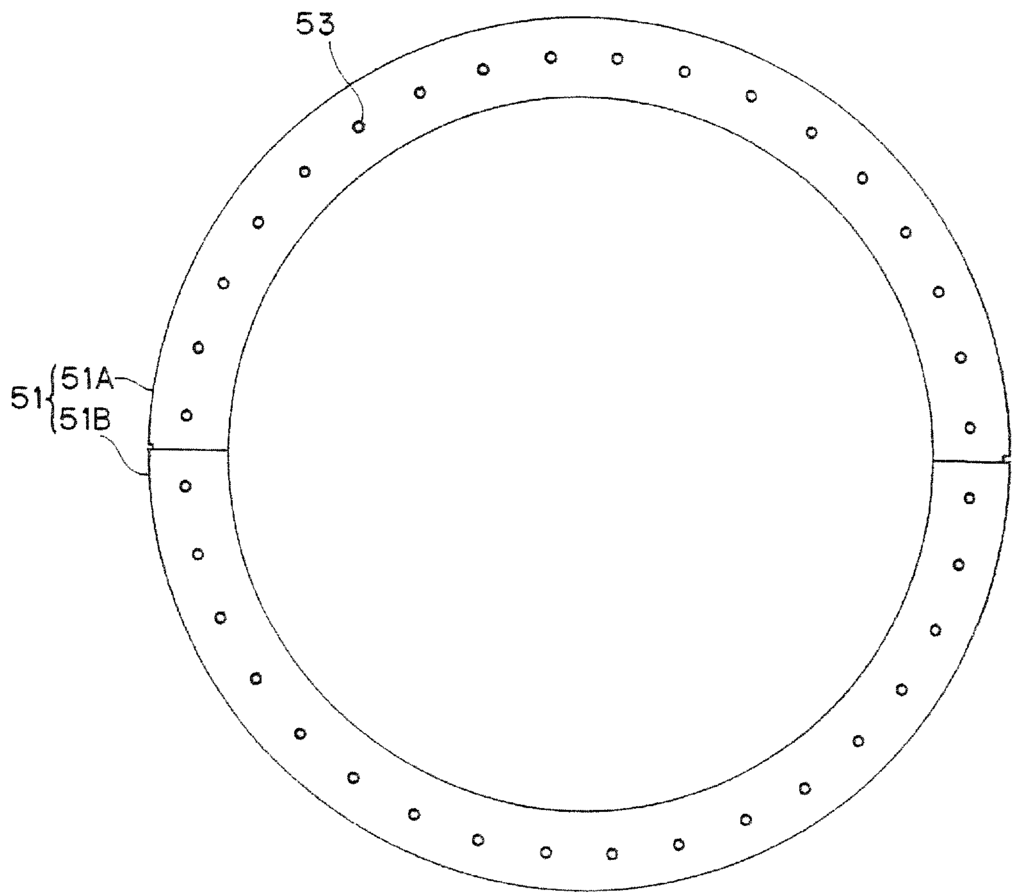
Fig.2

Fig.3



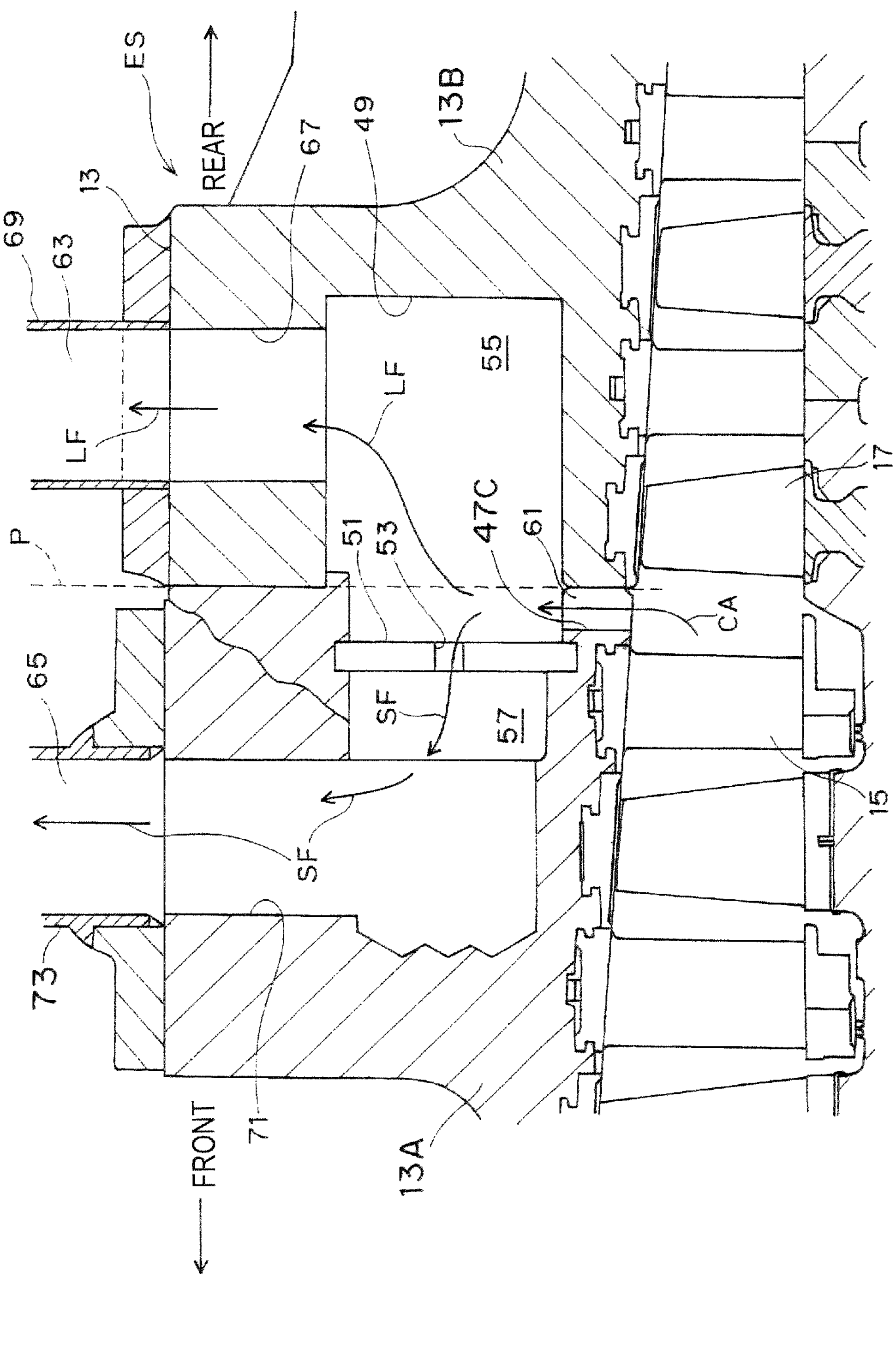

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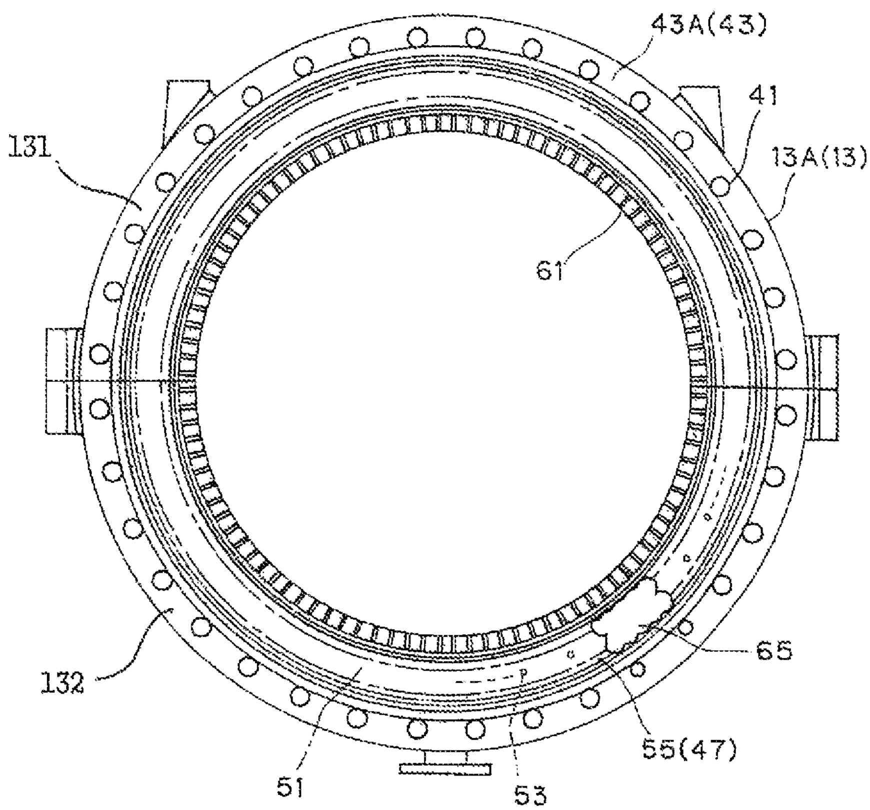
Fig.4

Fig.5



STRUCTURE FOR EXTRACTING COMPRESSED AIR FROM COMPRESSOR OF GAS TURBINE ENGINE AND GAS TURBINE ENGINE WITH THE STRUCTURE

TECHNICAL FIELD

The present invention relates to a structure for extracting a compressed air from a compressor of gas turbine engine. Also, the present invention relates to a gas turbine engine incorporating the structure.

BACKGROUND OF THE INVENTION

In a gas turbine engine with a multi-stage compressor, a compressed air generated by a compressor is in part used for the cooling of a turbine, for example. The compressed air is extracted from the compressor through a plurality of slits formed in a compressor housing at regular intervals in the circumferential direction so as to prevent a pressure drop in the air extracting zone and the resultant uneven pressure distribution in the compressor with respect to the circumferential direction.

For this purpose, JP 2001-304194 (A) discloses to provide various sizes of slits in order to extract various amounts of compressed air depending on usages of the extracted air. This technique may be advantageous in that a suitable pressure distribution is obtained for various amounts of air to be extracted.

On the other hand, the technique requires that the various sizes of slits are formed integrally in the compressor housing, which complicates design modifications of the slits according to the requirement of change in the amount of air. Also, the slits are defined by different members defining inward and outward portions of the compressor housing. This complicates a dimension control of, in particular, narrow slits for extracting smaller amount of air, which needs elevated size precisions. Therefore, an even pressure distribution may not be obtained within the interior of the compressor.

An object of the present invention is to provide a structure for extracting a part of compressed air generated by a compressor, which makes it easy to control a dimension of the narrow slits for extracting smaller amount of air and maintains an even pressure distribution within the interior of the compressor of the gas turbine engine by a simple arrangement defined therein.

SUMMARY OF THE INVENTION

To this end, a structure of a gas turbine engine for extracting a part of compressed air generated by a compressor, comprises

a cylindrical housing extending around an axis and forming therein at least a part of a compressing chamber in which air is flowed in a direction parallel to the axis as the air is compressed to generate the compressed air, the cylindrical housing having

an annular portion extending around the compressing chamber to define an annular chamber,

an annular partition dividing the annular chamber into an annular first plenum chamber and an annular second plenum chamber positioned on an upstream side of the first plenum chamber with respect to the direction and separated from the annular first plenum chamber,

the cylindrical housing further having a plurality of first apertures defined therethrough to communicate between the compressing chamber and said annular first plenum chamber;

the annular partition having a plurality of second apertures defined therethrough to communicate between the plurality of first and the plurality of second plenum chambers, the first and second apertures being configured so that the plurality of first apertures have a first total cross-sectional area and the plurality of second apertures have a second total cross-sectional area which is smaller than the first total cross-sectional area;

the annular second plenum chamber being in fluid communication with a second extracting passage for extracting the compressed air from the annular second plenum chamber.

2. The structure of claim **1**, wherein the first plenum chamber is in fluid communication with a first extracting passage for extracting the compressed air from the annular first plenum chamber.

According to the arrangement, because the second apertures with the smaller total cross section area are provided on the downstream side of the first apertures with the larger total cross section area, a substantially even pressure is established in the circumferential direction within the compressing chamber. Also, an amount of extraction air can be varied simply by changing the size of the second apertures.

In another aspect of the extraction structure for the gas turbine engine according to the invention, the first plenum chamber is in fluid communication with a first extracting passage for extracting the compressed air from the annular first plenum chamber.

In another aspect of the extraction structure for the gas turbine engine according to the invention, the first extracting passage has a valve provided therein for closing the first extracting passage.

In another aspect of the extraction structure for the gas turbine engine according to the invention, the cylindrical housing has a first housing portion and a second housing portion positioned on an upstream side of the first housing portion, the first and second housing portions having opposed first and second radially extending mating surfaces, respectively, which mate with each other in a sealing engagement when the first and second housing portions are assembled with each other, each aperture of the plurality of first apertures being defined by a recess, the recess comprising either respective recesses in the first and second mating surfaces or a single recess formed in one of the first and second mating surfaces, the first and second mating surfaces having annular first and second recesses defined therein, respectively, to form the annular chamber when the first and second housing portions are assembled with each other.

In another aspect of the extraction structure for the gas turbine engine according to the invention, the second housing portion is made of a plurality of housing segments, each housing segment of the plurality of housing segments having respective annular chamber portions forming a part of the annular chamber when the plurality of housing segments are assembled with each other, each of the respective annular chamber portions having inner and outer peripheral guides forming continuous annular inner and outer guides when the plurality of housing segments are assembled with each other, the annular partition being made of a plurality of partition segments, the plurality of partition segments being assembled to the plurality of housing segments with inner and outer peripheral edges thereof being guided by the inner and outer guides, respectively.

As described above, according to the extraction structure for the gas turbine engine of the invention, even the small amount of extraction air is controlled precisely. Also, an even pressure is established in the circumferential direction within the compressing chamber.

BRIEF DESCRIPTIONS OF THE DRAWINGS

FIG. **1** is a partially broken-away side elevation of a gas turbine engine which incorporates an extraction structure according to an embodiment of the invention;

FIG. **2** is a partial longitudinal cross section of the extraction structure in FIG. **1**;

FIG. **3** is a front view of an annular member used in the extraction structure in FIG. **1**;

FIG. **4** is a longitudinal cross section of the extraction structure taken on a longitudinal plane angularly different from that in FIG. **2**; and

FIG. **5** is a rear view of a front housing in the extraction structure in FIG. **1**.

PREFERRED EMBODIMENT OF THE INVENTION

With reference to the accompanying drawings, a preferred embodiment according to the invention will be described below.

FIG. **1** shows a partially broken-away side elevation of a gas turbine engine (hereinafter referred to as "engine") which incorporates an extracting structure according to an embodiment of the invention. The engine **1** comprises compressor **3**, combustors **5** and turbine **7** so that an intake air IA is compressed by the compressor **3** and then supplied to the combustors **5** where it is combusted with fuel F injected into the combustors **5** to generate a high-temperature and high-pressure combustion gas G which is used for driving the turbine **7**. In the following descriptions, left and right sides of the engine **1** with respect to a longitudinal axis C in the drawing will be referred to as "front/upstream" and "rear/downstream", respectively, as necessary.

According to the embodiment, the compressor **3** is an axial-flow compressor and comprises a compressor rotor **11**A which constitutes a front rotational portion of the engine. The front portion of the compressor rotor **11**A is surrounded by a two-fraction compressor housing **13** to define an annular compression chamber **30** between the compressor rotor **11**A and the compressor housing **13**. The compressor housing **13** supports a plurality stages of compressor stator blade wheels **15** positioned in the compression chamber **30** and spaced apart from each other in the longitudinal direction. The compressor rotor **11**A supports a plurality stages of compressor rotor blade wheels **17** positioned in the compressor chamber **30** and spaced apart from each other in the longitudinal direction so that each of the rotor blade wheels **17** is positioned on the upstream side of the associated stator blade wheel **15**, which allows the stator and rotor blade wheels **15** and **17** to cooperated with each other to compress the intake air IA drawn from the inlet **19**. The compressed air CA is then supplied into the combustors **5** through a diffuser **21** provided on the downstream side of the compressor **3**.

The combustors **5** are provided at regular intervals in the circumferential direction of the engine **1**, where the compressed air CA from the compressor **3** is mixed and combusted with fuel F injected into the interiors of the combustors **5** to generate a high-temperature and high pressure combustion gas G which is then supplied to the turbine **7** through a turbine nozzle **23** or the first stage stator blade wheel of the turbine.

The compressor rotor **11**A is connected to a high-pressure turbine rotor **11**B of the turbine **7**. A low-pressure turbine rotor **11**C is located on the downstream side of the high-pressure turbine rotor **11**B. The compressor rotor **11**A is supported for rotation by the compressor housing **13** through front and middle bearings **33**A and **33**B. The low-pressure turbine rotor **11**C is supported for rotation through the turbine shaft **11**D by the rear bearing **33**C.

The compressor housing **13** is made of a front housing **13**A surrounding the front to middle portion of the compressor rotor **11**A (e.g., first to seventh stage stator blade wheels) and a rear housing **13**B surrounding the middle to rear portion of the compressor **11**A (e.g., eighth to last stage stator blades). The front and rear housings **13**A and **13**B are connected to each other by connection bolts **41**. FIG. **2** shows details of the connection between the front and rear housings **13**A and **13**B. As shown in the drawing, an extraction structure ES for extracting a part of the compressed air CA from the compressor **3** is provided around a mating surface P or contact surface of the front and rear housings **13**A and **13**B.

The front and rear housings **13**A and **13**B have outwardly projecting annular flanges **43**A and **43**B integrally formed at rear and front connection ends thereof, respectively. For example, the front housing **13**A has annular front flange **43**A at its rear end and the rear housing **13**B has annular rear flange **43**B having the same outer diameter as the front flange **43**A. The front and rear flanges **43**A and **43**B have through holes extending parallel to the longitudinal axis and provided at regular intervals in the circumferential direction. Inserted through the holes are connection bolts **41** with external threads at distal ends thereof on which nuts **45** are tightened to bring the front and rear housings **13**A and **13**B into close connection with each other in the longitudinal direction.

As shown in FIG. **2**, the front and rear flanges **43**A and **43**B have rear and front end surfaces **44**A and **44**B, respectively, extending on a plane P and opposing to each other so that, when the front and rear housings **13**A and **13**B are assembled with each other, the rear and front surfaces **44**A and **44**B of the front and rear housings **13**A and **13**B mate with each other to form a seal therebetween.

The rear end surface **44**A of the front flange **43**A has an annular front recess **47** or groove defined therein and the front end surface **44**B of the rear flange **43**B has an annular rear recess **49** or groove defined therein so that, when the front and rear housings **13**A and **13**B are assembled with each other as shown in the drawing, the front and rear recesses **47** and **49** cooperated with each other to form an annular chamber **54** therebetween.

The front recess **47** of the front flange **43**A receives an annular partition or plate **51** which is independent of the front flange **43**A. As shown in FIG. **3**, the plate **51** has a number of second apertures **53** extending therethrough and provided at regular intervals in the circumferential direction. The plate **51** may be made of plural segments having the same size in the circumferential direction. In the embodiment, the plate **51** is made of two halves or semi-annular segments **51**A and **51**B. This arrangement ensures that the plate **51** is easy to be assembled in the compressor **3**. The plate **51** is supported by slidingly engaging its inner and outer circumferential edges in the annular engagement grooves **47**A and **47**B formed continuously in the opposing surfaces of the outer and inner circumferential walls **45**A and **45**B, defining radially opposed inner surfaces of the front recess **47**. In this embodiment, the front housing **13**A is divided into two halves (i.e., housing segments) **131** and **132** (see FIG. **5**) and the plate **51** is divided into two halves **51**A and **51**B (see FIG. **3**). Therefore, when assembling, one and the other halves of the plate **51** are slidingly engaged in one and the other halves of the grooves **47**A and **47**B of the front housing, respectively. Then, the two halves (i.e., housing segments) **131** and **132** of the front housing are assembled with each other to form the front housing **13**A.

The housing **13** has a number of through-holes or first apertures **61** communicating between the compressing chamber **30** and the annular chamber **54**, in particular, a first plenum chamber **55** described below. In the embodiment, the compressing chamber **30** and the annular chamber **54** are communicated with each other through communication apertures **61** defined by radially extending grooves **47**C in a rear end surface **44**A of the inner circumferential wall **45**B of the front housing **13**A. The communication holes may be made of either grooves **47**C defined in the rear end surface **44**A of the front housing **13**A or grooves defined in the front end surface **44**B of the rear housing **13**B or both, or of through-holes extending through the front or rear housing. The grooves are formed easier than the through-holes. In the embodiment, the communication apertures **61** are provided between the seventh stator blade wheel **15** and the eighth rotor blade wheel **17**, allowing a part of the compressed air to be introduced through the communication apertures **61** into the first plenum chamber **55**.

Once the front and rear housings **13**A and **13**B are assembled with each other, the annular chamber **54** positioned around the compressor housing **13** and surrounded by the flanges **43**A and **43**B is divided into the first plenum chamber **55** positioned on the rear side of the plate **51** and the second plenum chamber **57** positioned on the front side of the plate, the first and second plenum chambers **55** and **57** being communicated with each other through apertures **53** and the first plenum chamber **55** and the compressing chamber **30** being communicated through communication apertures **61**.

A total cross section area or total flow passage area of the apertures **53** is designed to be smaller than that of the communication apertures **61**. In the embodiment, the number of the apertures **53** is designed to be less than that of the communication apertures **61**. Also, in the embodiment, the number of the apertures **53** is designed to be about one half of the communication apertures **61** and the total cross section area of the apertures **53** is designed to be about 10% of the total cross section area of the communication apertures **61**.

FIG. **4** shows a cross section of the extraction structure ES taken along a longitudinal plane which is angularly different from that in FIG. **2**. As shown in the drawing, the first plenum chamber **55** is communicated with one or more first extraction passages **63** for extracting the compressed air from the first plenum chamber **55**. The second plenum chamber **57** is communicated with one or more second extraction passages **65** for extracting the compressed air from the second plenum chamber **57**. The first extraction passages **63** are each made of a first extraction hole **67** defined in the rear housing **13**B and a first extraction tube **69** connected to the first extraction hole **67**. The second extraction passages **65** are each made of a second extraction hole **71** defined in the front housing **13**A and a second extraction tube **73** connected to the second extraction hole **71**. Preferably, the first and second extraction holes **67** and **71** are formed on angularly different longitudinal planes.

As described above, because the total cross section area of the communication apertures **61** is set to be larger than that of the apertures **53**, the first extraction passages **63** work as a major extraction passage for extracting a larger amount of compressed air through communication apertures **61** and the first plenum chamber **55**. The second extraction passages **65**, on the other hand, work as a minor extraction passage for extracting a smaller amount of compressed air through the apertures **53** and the second plenum chamber **57**. The number of the extraction holes **63** and **65** are determined to obtain the necessary amount of extraction air. In this embodiment, the compressor housing **13** has two first extraction passages **63** provided at a regular interval in the circumferential direction and one extraction passage **65**.

In the embodiment shown in FIG. **1**, the major first extraction passage **63** is connected to an exhaust gas passage **31**. The exhaust gas passage **31** has a valve mechanism **77** so that the first extraction passage **63** can be closed by the valve mechanism **77** except that a large amount of compressed air is needed to be extracted through the first extraction passage **63**. The minor second extraction passage **65** is connected to a high-temperature portion of the engine, for example, a bearing chamber **81** which accommodates the middle bearing **33**B, so that the compressed air CA is guided to the high-temperature portion for its cooling.

Operations of the extraction mechanism according to the embodiment will be described below. When staring the engine **1** in FIG. **1**, a large amount of compressed air CA is preferably extracted to reduce a start-up torque. Then, the valve mechanism on the first extraction passage **63** is opened. This allows that the compressed air CA is guided through the communication apertures **61** (FIG. **5**) into the first plenum chamber **55** (FIG. **4**). In this instance, because the total cross section area of the first extraction passages **63** is sufficiently larger than that of the communication apertures **61**, the communication apertures **61** work as a reducer between the compressing chamber **30** and the first plenum chamber **55** to prevent an uneven pressure distribution in the circumferential direction within an interior of the compressor **3**.

Also, an amount of compressed air CA flowing through the communication apertures **61** into the first plenum chamber **55** is sufficiently larger than a maximum amount of air passing through the apertures **53**, calculated on the basis of the total cross section area thereof. In addition, the central axes of the apertures **53** are oriented parallel to the longitudinal axis and substantially orthogonal to the central axes of the communication apertures **61** and the first extraction passages **63** oriented in the radial directions. Therefore, a substantial part of the compressed air CA entered through the communication apertures **61** into the first plenum chamber **55** are guided as the major extraction compressed air LF into the first extraction passages **63** and then the exhaust gas passage **31**, rather than being guided through the apertures **53** into the second plenum chamber **57**.

In the normal operation of the engine **1**, the valve mechanism **77** of the first extraction passage **63** is closed so that only a small amount of air is extracted. In this operation, as shown in FIG. **2**, the compressed air CA in the compressor **3** is introduced as a small amount of compressed air SF through the communication apertures **61** into the first plenum chamber **55**. The communication apertures **61**, however, do not work as reducer because the total cross section of the communication apertures **61** is set to be larger than that corresponding to an amount of air being extracted. The total cross section area of the apertures **53** in the plate **51** sufficiently smaller than that corresponding to the amount of air being extracted, which ensures that an even pressure distribution is established in the first plenum chamber **55** and the compressing chamber **30**. Also, the plate **51** is formed independently of the compressor housing **15**. Therefore, the apertures **53** for controlling small amount of air are formed precisely. Also, the dimension, the number, the positions of the apertures can readily be modified for the specifications.

Although in the previous embodiment the major first extraction passage **63** is connected to the exhaust gas passage **31** in the starting operation of the engine **1** and the minor second extraction passage **65** is connected to the middle bearing chamber **81** for cooling, the extraction passage **63** and **65** may be connected to other internal and/or external portions of the engine **1** where different amounts of compressed air are needed, irrespective of the intended use.

In view of the foregoing, although preferred embodiments of the invention have been described with reference to the accompanying drawings, various additions, eliminations and/or modifications can be made without departing from the gist of the invention and they are within the scope of the invention. For example, although in the previous embodiment the plate **51** is mounted to the front housing **13**A by the sliding engagement in the circumferential grooves **47**A and **47**B of the front housing **13**A, it may be mounted in different ways such as using fixing rings. In this instance, the plate or partition may be fixed by nipping it between the ring and the annular front or rear end surface of the front or rear housing. Also, although the plate **51** is made of plural segments, it may be made of a single annular member. In this instance, the annular member is fixed using the fixing member or ring. Further, although in the previous embodiment the plate **51** is mounted in the front housing **13**A, it may be mounted in the rear housing **13**B.

PARTS LIST

1: gas turbine engine
3: compressor
13: compressor housing
51: plate (annular member)
53: aperture
55: first plenum chamber
57: second plenum chamber
61: aperture
63: first extraction passage (major extraction passage)
65: second extraction passage (minor extraction passage)
CA: compressed air
ES: extraction structure

The invention claimed is:

1. A structure of a gas turbine engine for extracting a part of compressed air generated by a compressor, comprising:

a cylindrical housing extending around an axis and forming therein at least a part of a compressing chamber in which air is flowed in a direction parallel to the axis as the air is compressed to generate the compressed air, the cylindrical housing having

an annular portion extending around the compressing chamber to define an annular chamber,

an annular partition dividing the annular chamber into an annular first plenum chamber and an annular second plenum chamber positioned on an upstream side of the first plenum chamber with respect to the direction and separated from the annular first plenum chamber,

the cylindrical housing further having a plurality of first apertures defined therethrough to communicate between the compressing chamber and said annular first plenum chamber;

the annular partition having a plurality of second apertures defined therethrough to communicate between the annular first and second plenum chambers, the plurality of first apertures and the plurality of second apertures being configured so that the plurality of first apertures have a first total cross-sectional area and the plurality of second apertures have a second total cross-sectional area which is smaller than the first total cross-sectional area;

the annular second plenum chamber being in fluid communication with a second extracting passage for extracting the compressed air from the annular second plenum chamber.

2. The structure of claim **1**, wherein the annular first plenum chamber is in fluid communication with a first extracting passage for extracting the compressed air from the annular first plenum chamber.

3. The structure of claim **2**, wherein the first extracting passage has a valve provided therein for closing the first extracting passage.

4. The structure of claim **1**, wherein the cylindrical housing has a first housing portion and a second housing portion positioned on an upstream side of the first housing portion, the first and second housing portions having opposed first and second radially extending mating surfaces, respectively, which mate with each other in a sealing engagement when the first and second housing portions are assembled with each other, each aperture of the plurality of first apertures being defined by a recess, the recess comprising either respective recesses in the first and second mating surfaces or a single recess formed in one of the first and second mating surfaces, the first and second mating surfaces having annular first and second recesses defined therein, respectively, to form the annular chamber when the first and second housing portions are assembled with each other.

5. The structure of claim **4**, wherein the second housing portion is made of a plurality of housing segments, each housing segment of the plurality of housing segments having respective annular chamber portions forming a part of the annular chamber when the plurality of housing segments are assembled with each other, each of the respective annular chamber portions having inner and outer peripheral guides forming continuous annular inner and outer guides when the plurality of housing segments are assembled with each other, the annular partition being made of a plurality of partition segments, the plurality of partition segments being assembled to the plurality of housing segments with inner and outer peripheral edges thereof being guided by the inner and outer guides, respectively.

6. A gas turbine engine, comprising:

a compressor for compressing air to generate compressed air;

a combustor for combusting the compressed air with fuel to generate a high pressure combustion gas; and

a turbine for rotating a rotor by using the combustion gas;

the compressor having a cylindrical housing extending around an axis and forming therein at least a part of a compressing chamber in which air is flowed in a direction parallel to the axis as the air is compressed to generate the compressed air, the cylindrical housing having

an annular portion extending around the compressing chamber to define an annular chamber,

an annular partition dividing the annular chamber into an annular first plenum chamber and an annular second plenum chamber positioned on an upstream side with respect to the direction and separated from the annular first plenum chamber,

the cylindrical housing having a plurality of first apertures defined therethrough to communicate between the compressing chamber and the annular first plenum chamber;

the partition having a plurality of second apertures defined therethrough to communicate between the annular first and second plenum chambers, the plurality of first apertures and the plurality of second apertures being configured so that the plurality of first apertures have a first total cross-sectional area and the plurality of second apertures have a second total cross-sectional area which is smaller than the first total cross-sectional area;

the annular second plenum chamber being in fluid communication with a second extracting passage for extracting the compressed air from the annular second plenum chamber.

7. The gas turbine engine of claim **6**, wherein the annular first plenum chamber is in fluid communication with a first extracting passage for extracting the compressed air from the annular first plenum chamber.

8. The gas turbine engine of claim **7**, wherein the first extracting passage has an on-off valve provided therein for closing the first extracting passage.

9. The gas turbine engine of claim **6**, wherein the cylindrical housing has a first housing portion and a second housing portion positioned on an upstream side of the first housing portion, the first and second housing portions having opposed first and second radially extending mating surfaces, respectively, which mate with each other in a sealing engagement when the first and second housing portions are assembled with each other, each aperture of the plurality of first apertures being defined by a recess, the recess comprising either respective recesses in the first and second mating surfaces or a single recess formed in one of the first and second mating surfaces, the first and second mating surfaces having annular first and second recesses defined therein, respectively, to form the annular chamber when the first and second housing portions are assembled with each other.

10. The gas turbine engine of claim **9**, wherein the second housing portion is made of a plurality of housing segments, each housing segment of the plurality of housing segments having respective annular chamber portions forming a part of the annular chamber when the plurality of housing segments are assembled with each other, each of the respective annular chamber portions having inner and outer peripheral guides forming continuous annular inner and outer guides when the plurality of housing segments are assembled with each other, the annular partition being made of a plurality of partition segments, the plurality of partition segments being assembled to the plurality of housing segments with inner and outer peripheral edges thereof being guided by the inner and outer guides, respectively.

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